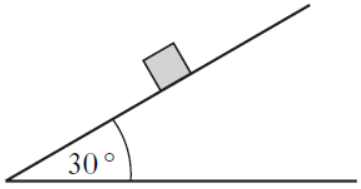
Forces in Equilibrium with Friction

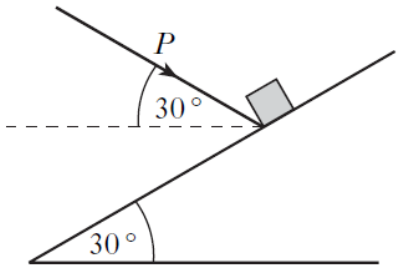
2005

A9. (*a*) A box of mass m kg is placed on a rough plane inclined at 30° to the horizontal. The coefficient of friction between the box and the plane is μ.



Given that the box remains in equilibrium, show that $\mu \geq \frac{1}{\sqrt{3}}$. **3**

(*b*) The same box is kept in equilibrium on another rough plane, which is also inclined at 30° to the horizontal, by the action of a force of magnitude P newtons as shown in the diagram below. This force is acting up the plane at an angle of 30° to the horizontal. The coefficient of friction between the box and this plane is 0·5 and the box is on the point of slipping down the plane.



(i) Show that the reaction force normal to the inclined plane has magnitude given by

$$R = \frac{\sqrt{3}}{2}(mg + P) \text{ newtons.}$$ **2**

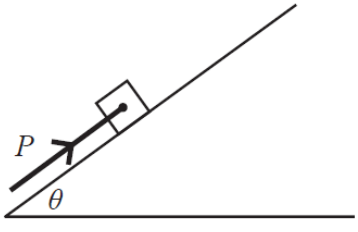
(ii) Show further that

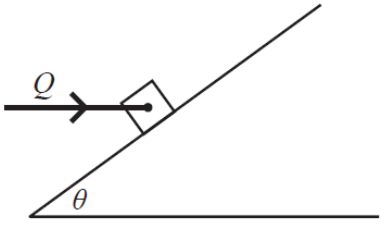
$$P = \frac{(2-\sqrt{3})mg}{2+\sqrt{3}} \text{ newtons.}$$ **5**

2016

14. A block of weight W is placed on a rough inclined plane at an angle θ to the plane.

It can be held on the point of slipping down the plane by a force P acting parallel to the plane or a horizontal force Q as shown by the diagrams.

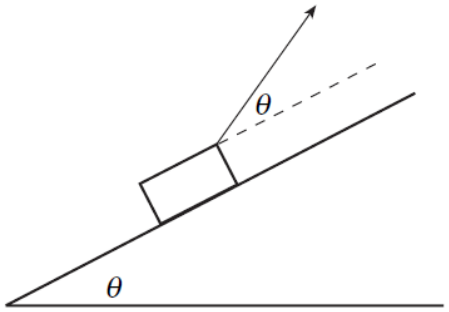




Prove that $P = \frac{QW}{Q\sin\theta + W\cos\theta}$. **7**

2006

A7. Alan pulls a container with weight of magnitude W newtons at a constant speed up a rough plane, with coefficient of friction μ, inclined at an acute angle θ to the horizontal by means of a light inextensible rope, as shown below. The rope also makes an angle θ to the inclined plane.



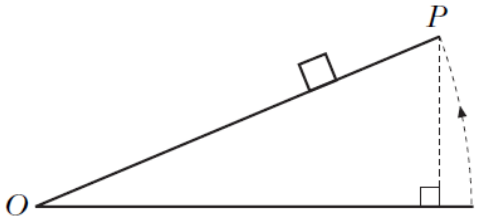
(*a*) Show that the magnitude of the tension in the rope is given by

$$\left(\frac{\tan\theta+\mu}{1+\mu\tan\theta}\right)W \text{ newtons.}$$ **6**

(*b*) Determine the range of values of θ for which the tension in the rope is less than the weight of the container. **4**

2008

A3. A rough ramp OP of length 6 m is hinged at O. A point P at the other end is able to move about O in a vertical plane as illustrated in the diagram.
A small box of mass 2 kg is in equilibrium on the ramp.



(*a*) When P is 2 m above the horizontal plane through O, the box is on the point of sliding down the ramp. Calculate the coefficient of friction between the box and the ramp. **2**

(*b*) P is now raised to a height of 4 m above the horizontal plane. A force of F newtons, applied to the box and acting parallel to the ramp, is just sufficient to prevent the box from sliding down the ramp. Calculate the magnitude of F. **3**